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indicating that pneumatolitic action was an important agency in their origin. The fissure deposits are associated with the complementary dikes and contemporaneous or slightly later quartz veins, and include replacement deposits in the wall rock. They occur principally in the granodiorite. The fissures have a steep southerly dip.

The post-Miocene deposits are argentiferous gold ores. They occur in quartz-adularia fissure veins in the old rhyolite in the Jarbidge district. They were discovered late in 1909. The fissures are mostly contained in two main systems which converge downward. Those of the west system dip steeply to the east and those of the east system dip steeply to the west. The gangue is pseudomorphic after calcite and rhyolite and was deposited by ascending thermal solutions that dissolved out and replaced the earlier calcite gangue.

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*Sandstone of the Wisconsin Coast of Lake Superior.* By FREDERIK TURVILLE THWAITES. Bull. No. XXV, Wisconsin Geol. and Nat. Hist. Surv. Pp. 117+viii. Plates XXIII. Madison, 1912.

The stratigraphic relations and geologic age of the red sandstones of the Lake Superior region have long been a subject of discussion arising from the fact that the older sandstones are closely allied to the Keweenawan while the younger beds partake more of the general characteristics of the Cambrian. The older sandstones are characteristically composed of arkose material and the strata are nearly always tilted. The younger group is almost wholly quartz sandstone, and its beds are generally horizontal. Both series, so far as known, are entirely devoid of organic remains. Former investigators recognized that the lower group was a part of the Keweenawan series, but opinions differed as to its relation to the upper; some held that the two were conformable, while others maintained that an unconformity existed and that the upper group probably corresponded to the Cambrian of southern Wisconsin, or its conformable downward extension.

One of the principal results of the present study was the conclusion that the upper quartz sandstone grades conformably downward into red shales and arkose sandstones which possess the same characters as the main body of the recognized Keweenawan sediments. As no conclusive evidence was discovered which tended to indicate that the two groups are unconformable, the facts are believed to warrant the belief that the sandstones form a single essentially conformable series. What has

heretofore been called the "western sandstone" (here called the Bayfield group) is united by Thwaites with the underlying Upper Keweenawan arkose sediments (here called the Oronto group) as one continuous formation. The results of this work show that the contact of the upper, or Bayfield, group with the Middle Keweenawan traps is a fault. At this contact there is some evidence of unconformity, but the author, following Van Hise and Leith, regards it as certain that the folding, faulting, and erosion went on during the deposition of the entire sandstone series, and that the upper beds therefore overlapped with slight unconformity upon the older strata of the same series. The difference in the degree of folding of the two groups of sandstone is correlated with this fact. Both groups were probably deposited subaerially in a basin formed by the bowing of the earlier Keweenawan rocks. They comprise an enormous thickness of sediments, perhaps amounting to as much as 25,000 feet measured in the ordinary way. But the thick series was laid down while deformation of the region was in progress and thus embraces beds which overlap and shingle one another, greatly lessening the total bulk of the formation.

The results of this study, while throwing much light upon the stratigraphic relations in the Lake Superior district, do not in any way determine the relation of the Keweenawan to the Cambrian of the Mississippi Valley. But the fact that the Bayfield group was involved in the profound deformation of the Keweenawan period contrasts it sharply with the slightly disturbed strata of the recognized Cambrian of Wisconsin and Minnesota. The Bayfield group as here interpreted seems, therefore, to be more closely allied to the Keweenawan than to the Cambrian. But this may be apparent rather than actual. For it is not unreasonable to suppose, as Van Hise and Leith have suggested in their *Lake Superior Monograph*, that subaerial sedimentation may have continued within this inland basin nearly or quite up to the time when the advancing Upper Cambrian sea entered the Lake Superior basin. It may therefore be that these sandstones deposited on land may bridge the gap between Proterozoic and Paleozoic. But until the relation of these sandstones to the fossiliferous beds of proven Cambrian age can be determined, the question of the age of the red sandstones still remains a debatable one. It is greatly to be hoped that the author will be able to carry the investigation farther in the endeavor to connect the Lake Superior sandstones with the fossiliferous St. Croix beds lying to the southwest in Minnesota, or with the Cambrian beds lying to the eastward in Michigan.

R. T. C.